

A 3D cutaway diagram of a complex particle accelerator or detector component. The diagram shows various internal structures, including a central beam pipe, surrounding magnets, and support structures. The components are color-coded: red for the main body, blue for internal structures, green for a central component, and yellow for other parts. The background is a light blue gradient.

Software and simulation status

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Overview

- ▶ Provide a snapshot of sPHENIX software status. Highlight **on-going** and **missing** studies/developments
 - **Ready**: run out of box from the default macro
 - **on-going** : please contact author if plan to use/contribute
 - **missing** : missing item, please join and lead the charge!
- ▶ Hyperlinks (green text) for more information
- ▶ Let me know if miss anything. Intend to convert these slides to a wiki page



Status by sPHENIX components



Software framework

- ▶ Based on PHENIX software framework, a.k.a. Fun4All
 - Naturally supports pause analysis at any reconstruction stage (e.g. simulation/reconstruction/analysis or any sub steps), store intermediate data to file (a.k.a. DST file or PHENIX formatted ROOT file), and resume in another Fun4All reconstruction cycle
 - Naturally supports embedding, e.g. single particle in to A+A or Pythia8 p+p jet into A+A
 - Naturally supports event filtering, e.g. trigger on generator level (e.g. [PHTy8JetTrigger](#)) or reco level (easy to write when needed)
 - During event processing, reco data available in memory ([PHCompositeNode](#)) for user to write a module to analyze on-the-fly or choose to save relevant parts to user-defined Ntuple
 - Event mixing via analysis code
- ▶ Built-in Geant4 support
 - Constructs detector in Geant4 via C++ (Expert built and maintained)
 - Calls Geant4 track input primary particles, Record digested Geant4 hits
 - Deep truth ancestry tracing tool throughout analysis chain
 - Common macro run the simulation and standard analysis chain
- ▶ Easy access for user modules in analysis
https://wiki.bnl.gov/sPHENIX/index.php/Example_of_using_DST_nodes
- ▶ Read more: [Introduction to Fun4All](#), [Running sPHENIX simulation](#)

Event generator

- ▶ Standard inputs: HEPMC format
 - [Fun4AllHepMCInputManager](#) -> [HepMCNodeReader](#)
- ▶ Ready-to-use generators
 - Pythia8 for p+p: [PHEPythia8](#)
 - Hijing for p+A, A+A
 - option for after-burner of flow: [flowAfterburner](#)
 - Some home-brewed format of EIC Pythia6 input: [ReadEICFiles](#)
 - Of-course single particle generator for testing
- ▶ On-going work:
 - Pythia6 for p+p/e+p: (From Nils Feege, [in review](#))
- ▶ **Need:**
 - Hard probes with media modification (e.g. YaJEM and JEWEL explored by Dave Morrison)

Tracking Simulation

- ▶ Ready:
 - Cylinder shaped silicon tracker available
 - TPC + digitization
 - Ganging readout strips
 - Randomized dead channels
- ▶ Standard design options in standard macro:
<https://github.com/sPHENIX-Collaboration/macros/tree/master/macros/g4simulations>
 1. Default: PHENIX VTX + RIKEN new strip layers in MIE: [G4_Svtx.C](#)
 2. PHENIX VTX + new TPC: [G4_Svtx_pixels+tpc.C](#)
 3. Maps inner pixel + RIKEN new strip layers: [G4_Svtx_maps+strips.C](#)
 4. Maps inner pixel + TPC: [G4_Svtx_maps+tpc.C](#)
 5. Full Maps (variation of ITS): [G4_Svtx_ITS.C](#)
- ▶ In development
 - Ladder based silicon tracker geometry (Tony Frawley)
 - Continue tuning for tracking options (tracking group)

Tracking reconstruction

- ▶ Ready
 - Pattern recognition: hough transform based helical pattern reco in uniform field ([PHG4HoughTransform](#))
 - Ghost/Fake rejection ([PHG4TrackGhostRejection](#))
 - Kalman filter for cylindrical tracker ([PHG4HoughTransform](#))
 - Track extrapolation (homogeneous field, [PHG4SvtxTrackProjection](#))
 - Vertex finder via global minimal ([VertexFinder](#))
 - Performance evaluator ([SvtxEvaluator](#))
- ▶ On-going:
 - Generic Kalman filter (exploring GenFit v2 by Haiwang Yu)
 - Better handle of fake rejection (e.g. using calorimetry matching by Kurt Hill and Ron Belmont)
 - Quantification and comparison of silicon tracker options (tracking group)
- ▶ **Need**
 - Generic vertex finder including secondary vertex (GenFit+Rave?)
 - Generic pattern recognition including forward trackers (OLYMPUS tree-search?)

Calorimetry Simulation

▶ Ready

- Detailed EM calorimeter sim based on UCLA SPACAL prototype and current sPHENIX engineering design of enclosure ([PHG4SpacalSubsystem](#))
- Detailed Hadron calorimeter based current sPHENIX engineering design ([PHG4InnerHcalSubsystem](#) and [PHG4OuterHcalSubsystem](#))
- Tower scheme with geometry description
- Shower truth compression and association
<https://github.com/sPHENIX-Collaboration/coresoftware/pull/101>

▶ On-going:

- Fast calorimetry simulations (Kurt Hill and Ron Belmont)
- Tuning models: light collection, variation, hadron interaction model (calorimeter groups, test beam)
- Calibration scheme (EMCal via pi0 by Vera Loggins)

Calorimetry reconstruction

- ▶ Clusterizer
 - Ready: a toy graph Clusterizer that connect all neighboring non-zero suppressed towers
 - Need performance check: PHENIX EMCAL clusterizer (Alexander Bazilevsky)
 - **Missing**: realistic Clusterizer that support non-spherical shower in full background
 - Especially important for γ -jet topical study
- ▶ Track – calorimeter association
 - Track projection based Clusterizer (ready)
 - Likelihood macro tool for electron ID (ready). Need to formulate a standardized module (**missing**)

Jet tools

- ▶ Baseline jet reco ([JetReco](#))
 - Input: truth, track, tower, cluster
 - Algorithm: FastJet-based Clusterizer, i.e. Anti-kT, etc.
 - Output: Reconstructed jets, support deep truth association
- ▶ Exploratory:
 - CMS-style flow jet: [PHFlowJetMaker](#) by Javier Orjuela Koop
- ▶ Need
 - B-jet tagging (in fast truth sim so far by Dennis V. Perepelitsa)
 - Background subtraction (coded in PHENIX software, need to be migrate over to sPHENIX and conform with code standard)
 - Formalize fake rejection, some quick form in PHENIX code base. Need to improve/port over to sPHENIX

Simulation production

- ▶ Managed by Chris Pinkenburg. Output to : RCF:/sphenix/sim/sim01/production/
- ▶ Standard set with full detector Geant4 information stored
 - 1000 particle per setting / X 4 eta bin / X 10 momentum bins / X 9 particle species
 - Reproducible in ~1 day
- ▶ Standard Hijing set in full detector
 - 1000 event per setting
 - $b = 0-4\text{fm}$, $b \sim 8\text{fm}$
 - Reproducible in ~1 day
- ▶ On demand production sets
 - 100k single particle per setting for resolution tail study
 - Tracking only Hijing->G4 simulation with 100k level event
 - Rare event -> Hijing embedding in full detector by reusing a small sample Hijing full detector simulation
- ▶ Computing facility:
 - RACF @ BNL: 10k CPU for single particle simulation, 500 CPU for Hijing related high memory simulation, 200 TB (production)/100 TB (user) base disk and expanding
 - Possible future for OpenScienceGrid (VO lead by Martin Purschke)
- ▶ Run yourself time cost:
 - Geant4: ~1s / single particle, ~20min / Hijing event
 - Reconstruction: ~1s / embedded Au+Au event

Beyond default sPHENIX

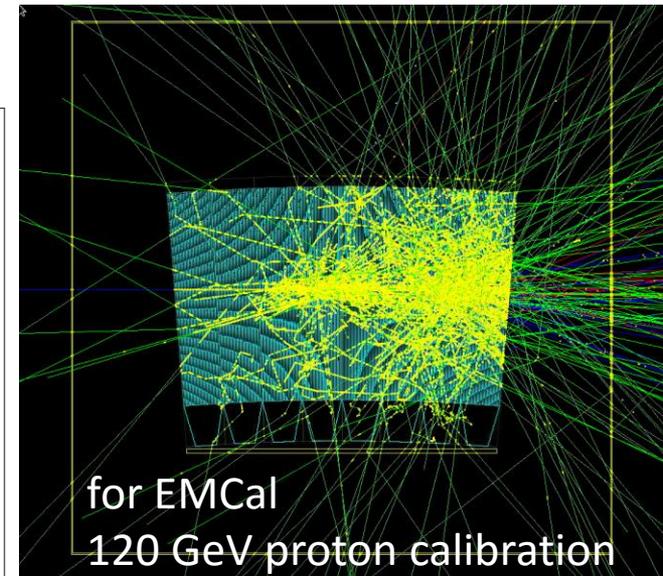
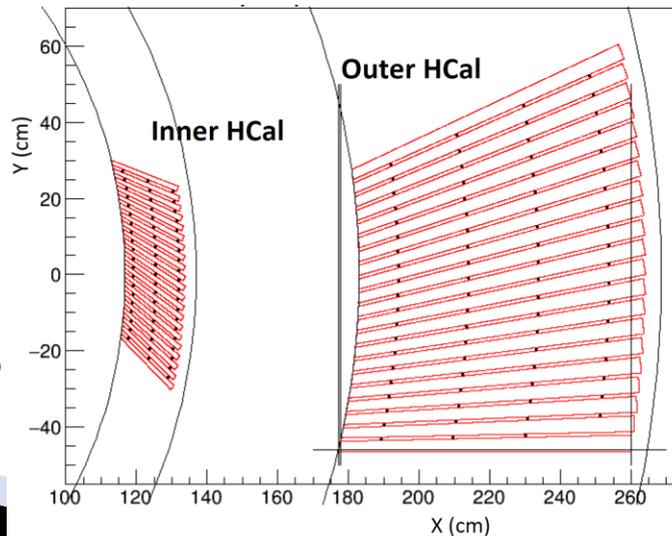
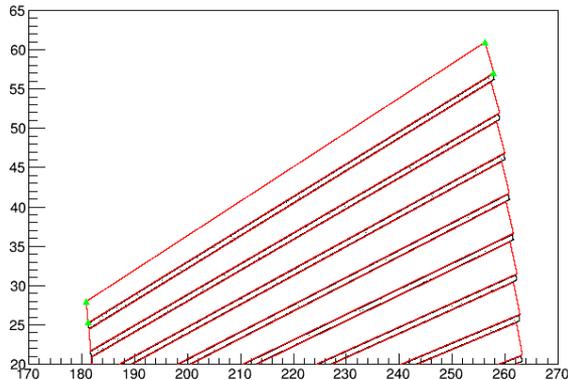


Calorimeter prototypes

- ▶ GSU group significantly contributed to simulation and analysis of the 2014 prototype
- ▶ On-going
 - Apr 2016 test beam simulation (Chris Pinkenburg, Murad Sarsour, Jin Huang)
 - Online analysis software (Abhisek Sen)

HCal geometry check from Chris and Murad

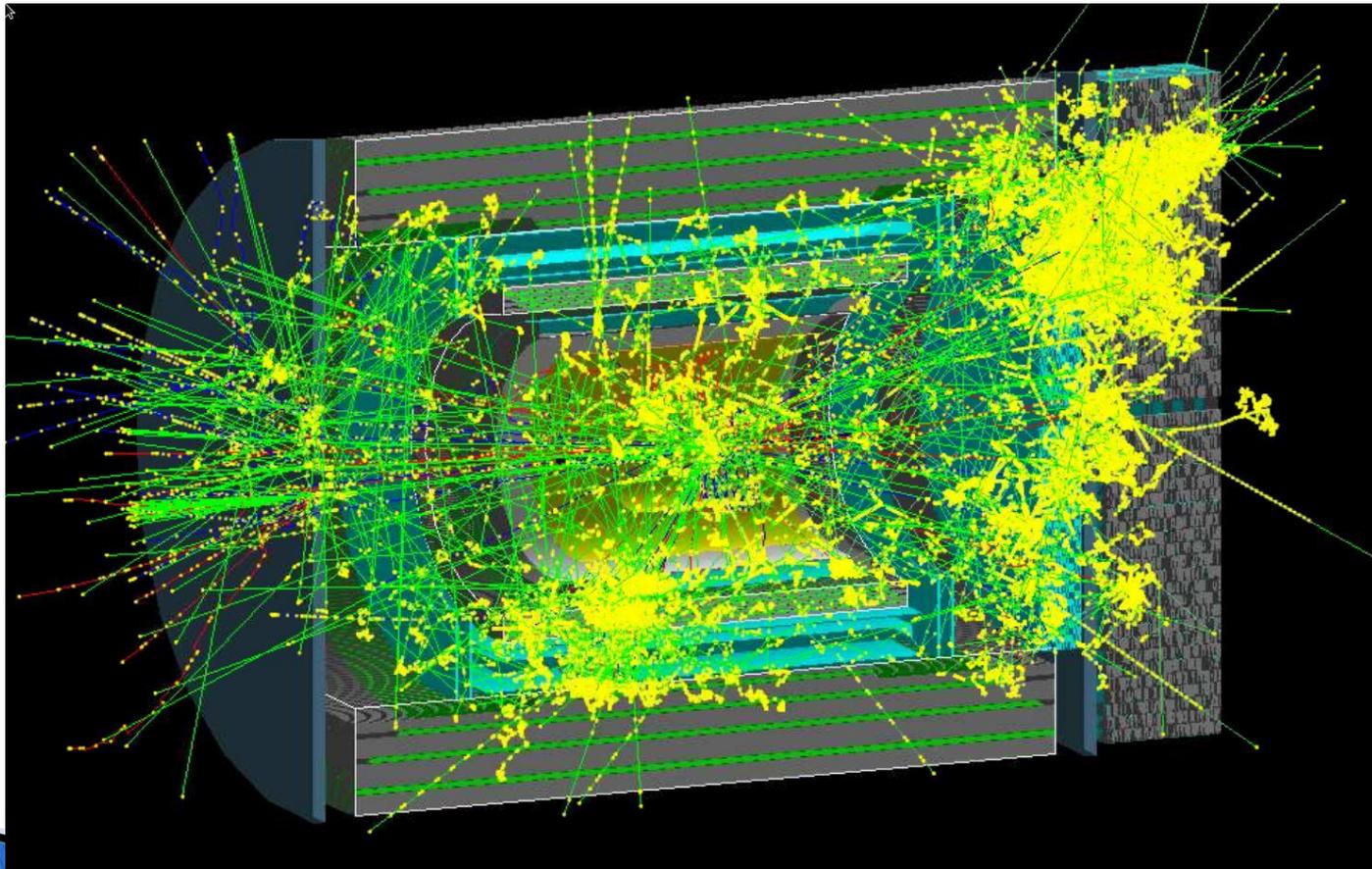
top outer steel



As well as supports on forward/EIC detectors (see next talk)

on-going work

https://wiki.bnl.gov/sPHENIX/index.php/Tutorial/fsPHENIX_simulation



How to get involved



How to get involved

- ▶ Discussion group:
 - sPHENIX simulation meeting: <https://indico.bnl.gov/categoryDisplay.py?categId=88>
 - Software and repository email list:
 - <https://lists.bnl.gov/mailman/listinfo/sphenix-software-l>
 - <https://lists.bnl.gov/mailman/listinfo/sphenix-github-l>
- ▶ Documentation
 - Software wiki: <https://wiki.bnl.gov/sPHENIX/index.php/Software>
 - Always good to start with [day-1 checklist](#)
 - Please search your email for read password/open writable account registration with ITD
 - Doxygen software reference: <https://www.phenix.bnl.gov/WWW/sPHENIX/doxygen/html/>
- ▶ Resource
 - RCAF
 - Expect to work with both PHENIX and STAR(in testing) existing RCF account
 - 100 TB (user) base disk and expanding (in testing with the new sphenix group ID)
 - sPHENIX code repository: <https://github.com/sPHENIX-Collaboration>